Space Weather Technical Forecast

Issued on Thursday, 20 January 2022 at 12:43 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Slight chance G1/Minor Storm intervals from CME arrivals throughout. S1/Minor solar radiation storm in progress. Active high energy electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: There are five numbered sunspots containing active regions on the Earth-facing disc. Solar activity reached Moderate levels as AR2929 (Dso/Beta-gamma), approaching the western limb, produced an M5 flare at 20/0601 UTC. An associated CME followed soon after, with a filament eruption from the southwest quarter, around 20/0800-0830 UTC, also producing a CME. Both CMEs are awaiting model analysis.

The remaining spots groups showed little activity, or changes in complexity. AR2930 (Dsi, Beta) is the next largest, and modestly complex group, which is also approaching the west limb, and lies to the north of AR2929. AR2927 Axx/Alpha and AR2933 Cao/Beta are small regions, lying the southwest quadrant. Newly numbered region AR2934 (Hsx/Alpha) continues to rotate into the southeast quadrant from the southeast limb.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1 decreased from 630 km/s to 480 km/s. Density was at mostly average levels, peak 11ppcc at around midnight UTC. The total interplanetary magnetic field strength (IMF), Bt, was weak 3-5nT. The north-south component weakly variable +4nT to -1nT. Phi angle was slightly positively pointed (away from the Sun), but became negative (toward the Sun) from around midnight UTC. Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) measured at GOES 16, increased following the M5 flare with the S1 level being exceeded around 20/0800UTC, with a current peak of around 23pfu and on ongoing S1 radiation storm. The 100MeV proton flux also rose to the 1pfu level around 20/0720 UTC, and has remained near this level since. High energy electron flux (greater than 2MeV) measured at GOES 16 was at mostly High levels, with a peak value of 3170 pfu at 19/1645 UTC. Electron fluence persisted above the 1e8 Active threshold with 20/0000 UTC observation value of 1.22e8 integrated pfu recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: There continues to be a slight chance of further isolated Moderate flares as AR2929 rotates around the west limb, however this risk should diminish through the period, barring any new sunspot development elsewhere on the visible disc.

Solar Wind / Geomagnetic Activity: There are three potential CME arrivals through the period, along with the two CMEs produced this morning UTC being analysed at present.

There is a slight and diminishing chance of a glancing impact on day 1 (20th) from a CME from

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the C2 flare on the 16th, and a glancing impact is also possible either late day 2 (21st) or early day 3 (22nd) from the CME from the M-flare on the 19th. Both of these are low confidence with the bulk of the CME material missing, passing ahead and to the north of Earth. A further slower, and weak CME on the 19th has the potential to arrive day 4 (23rd), but confidence is low on impacts due to the slow CME speed along with background solar winds being forecast to gradually decline to ambient levels by this stage. Geomagnetic activity is forecast to be mostly Quiet to Unsettled with isolated Active intervals possible, but a slight chance of increasing Active to G1/Minor storm levels from any CME arrival.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is forecast to slowly decrease back below the S1 level, most likely later on day 1, with a gradual return to background levels through the next four days. The high energy electron flux (greater than 2MeV) is expected to be continue to at mainly High flux levels through the period, but any CME arrival is likely to bring a noticeable dropout with mainly Moderate, perhaps peak high flux levels following. The 24-hour fluence is forecast to persist above the Active threshold, but with an increasing chance of dropping below this level through the period.

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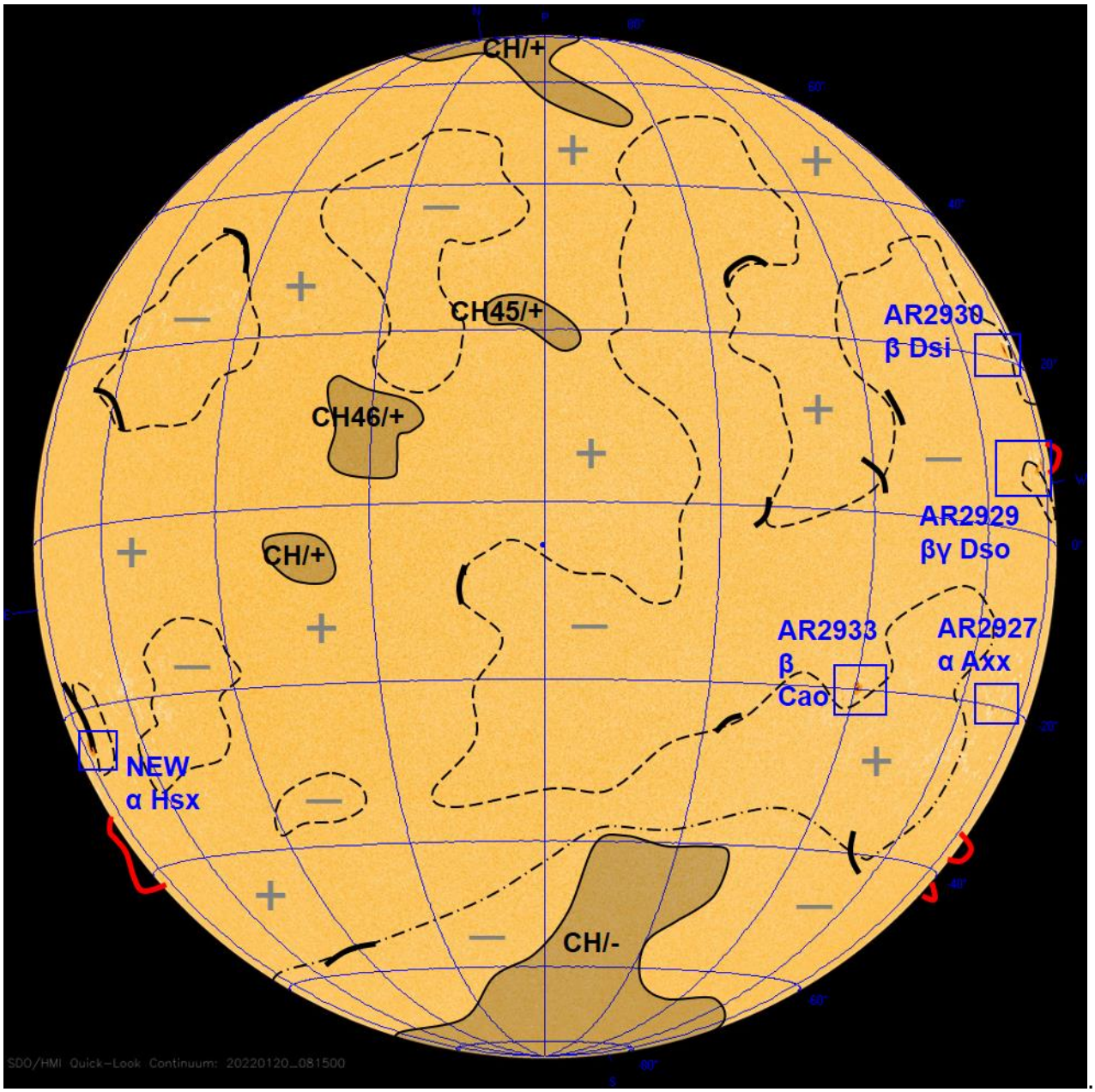
Figure 1. Solar Analysis Valid 20/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are a number of CMEs that have left the Sun in the last few days which may have Earth-directed components. Two further CMEs with possible Earth directed components, from the M5 flare and a filament eruption shortly after, are awaiting model analysis.

A long duration C2 flare on the 16th resulted in a CME which whilst predominately directed north and ahead of Earth, has the diminishing potential for a glancing impact on day 1 (20th). With solar winds currently elevated from the recent fast wind enhancements, and the CME arrival on late on the 18th, any further interaction has the potential to bring G1-Minor Storm conditions for a time. Otherwise solar winds are expected to continue gradually declining
A second CME has the potential to give a glancing impact either late day 2 or early day 3 (21st or 22nd). This is from the M1.5 flare of AR2929, and whilst again the bulk of the CME is directed north and ahead of Earth in its orbit, a glancing interaction is possible. This again bringing a slight chance of G1/Minor Storm intervals.

A third Earth-directed CME was observed primarily on STEREO A but also very faintly on SOHO LASCO on the 19th. This is from a large filament that weakly lifted around 19/0200 UTC. Unlike the previous CMEs, this is a less energetic lift, but from a more conducive location for moving across Earth. Due to its weaker nature, confidence is lower on potential impacts, however, with increased confidence for this to move across Earth, a slight chance of G1/Minor Storm intervals is maintained for day 4 (23rd).

Otherwise winds are expected to gradually ease a background through the period, although a small northward extension of the southern polar coronal hole brings a slight chance of further slightly elevated solar winds day 3 onward (22nd). Geomagnetic activity is forecast to be Quiet to Unsettled with a decreasing chance of Active intervals throughout. But with a slight chance of increasing to Active to G1 Minor Storm on any day, due to the potential CME arrivals.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	10	20	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
17/0235	Partial	C2 flare	24W 10N	562	20/0200	Likely missing – but chance of glance (20%)
18/2140	Partial	M1.5 flare of AR2929	58W 11N	950	22/0000	Bulk missing – only weak sideswipe

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						expected
19/1837	Partial	Filament	17W 16S	288	23/1500	Low confidence with fit, as very weak on SOHO

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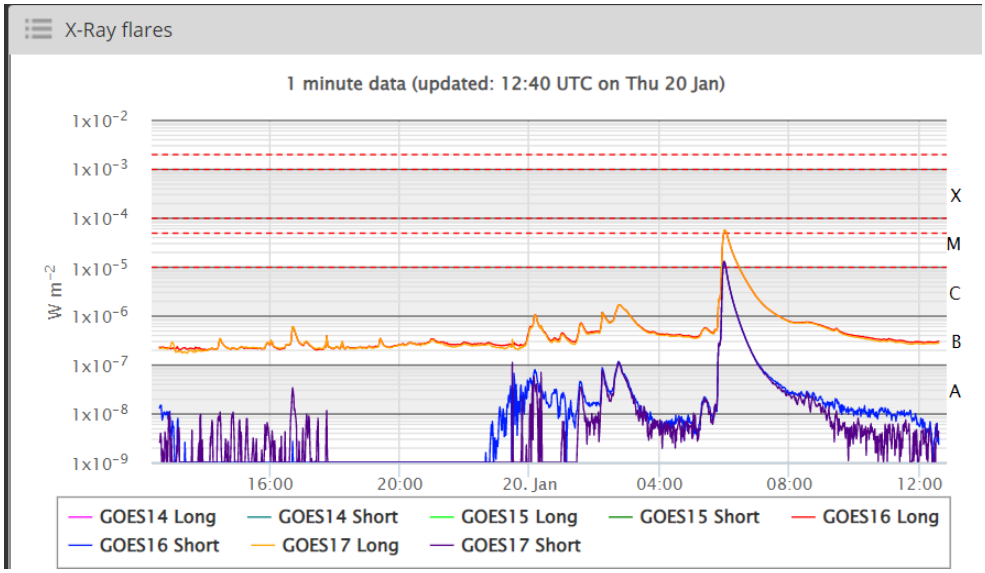
Radio Blackouts - X-Ray Flares:

There are five numbered sunspots containing active regions on the Earth-facing disc, and a number of other plage or old active regions. Solar activity reached Moderate levels as AR2929 (Dso/Beta-gamma), approaching the western limb, produced an M5 flare at 20/0601 UTC. An associated CME also followed soon after. This is currently being modelled, although most of the ejecta should be directed away from Earth.

The remaining spots groups showed little activity, or changes in complexity. AR2930 (Dsi, Beta) is the next largest, and modestly complex group, which is also approaching the west limb, and lies to the north of AR2929. AR2927 Axx/Alpha and AR2933 Cao/Beta are small regions, lying the southwest quadrant. Newly numbered region AR2934 (Hsx/Alpha) continues to rotate into the southeast quadrant from the southeast limb.
There continues to be a slight chance of further isolated Moderate flares as AR2929 rotates around the west limb, however this risk should diminish through the period, barring any new sunspot development elsewhere on the visible disc.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	20	20	10	5
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 2: GOES X-ray flux data.



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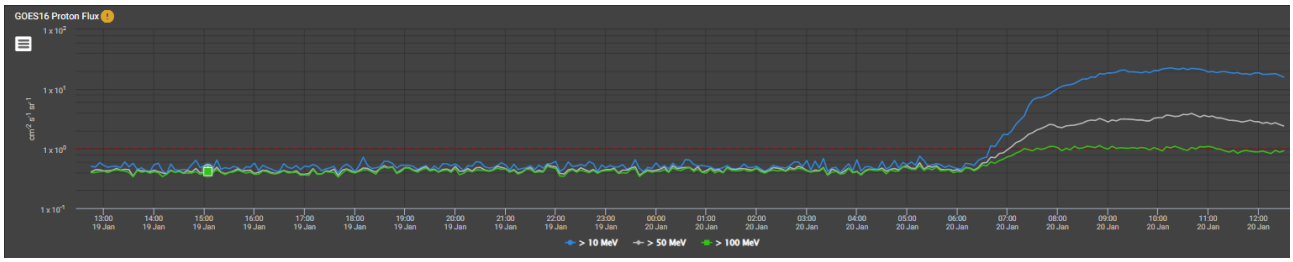
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16, increased following the M5 flare with the S1 level being exceeded around 20/0800UTC, with a current peak of around 23pfu and on ongoing S1 radiation storm. The 100MeV proton flux also rose to the 1pfu level around 20/0720 UTC, and has remained near this level since. High energy proton flux is expected to slowly decrease back below the S1 level, most likely later on day 1, with a gradual return to background levels through the next four days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	10	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: GOES16 proton flux data.



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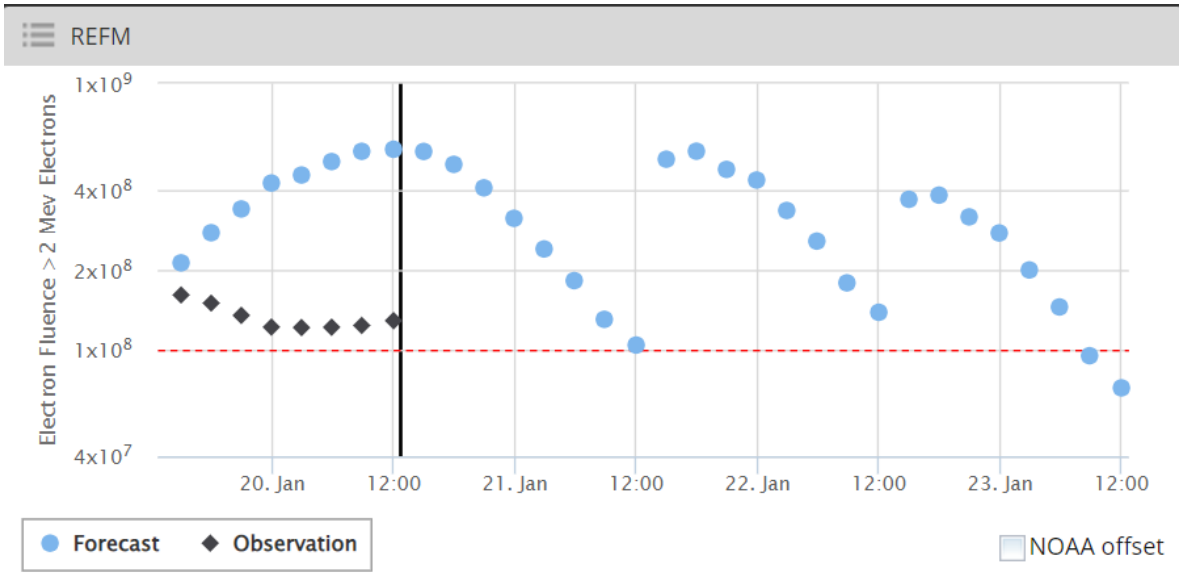
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as measured by GOES-16 at GEO, is currently High after recent fast wind and CME enhancements. In the absence of any CME arrivals, these high levels would be expected to persist for much of the period, with just a gradual declining trend. However there is a chance that any CME that does glance across the Earth will bring a noticeable dropout, with levels falling to background and perhaps only recovering to Moderate with peak High levels. There are three potential such CME arrivals, early day 1 (20th) around midnight day 2 (21st) into day 3 (22nd) and again day 4 (23rd). The first two of these are low confidence, but the third is anticipated but expected to be weaker. Despite this, a drop out in flux is likely by day 4 (23rd), with a chance of occurring before that. Two further CMEs with possible Earth directed components, from the M5 flare and a filament eruption shortly after, are awaiting model analysis.

The associated fluence is currently Active (above 1e8 integrated pfu) and expected to persist at this level, but with an increasing chance of falling below due to any flux drop out that occurs, and likely falling below later day 4 (23rd) with the arrival of the third CME. This persistent high flux is supported by REFM, although absolute values indicated by the model are considered too high.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	80	60	50
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: MOSWOC REFM.



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